Mod 6 – Ethernet Fundamentals
Evolution of Ethernet and Half-Duplex (CSMA/CD)

Cabrillo College

CIS 81 and CST 311

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Spring 2006

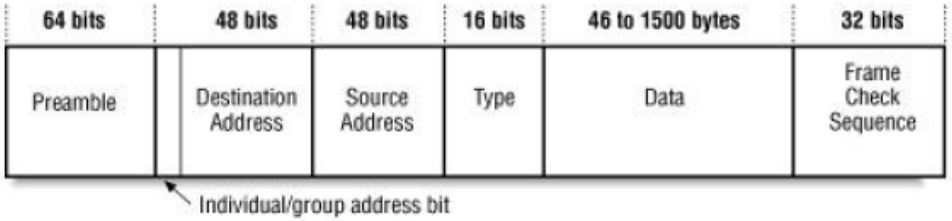
Note to instructors

- If you have downloaded this presentation from the Cisco Networking Academy Community FTP Center, this may not be my latest version of this PowerPoint.
- For the latest PowerPoints for all my CCNA, CCNP, and Wireless classes, please go to my web site:

  http://www.cabrillo.edu/~rgraziani/

  - The username is *cisco* and the password is *perlman* for all of my materials.
- If you have any questions on any of my materials or the curriculum, please feel free to email me at graziani@cabrillo.edu (I really don't mind helping.) Also, if you run across any typos or errors in my presentations, please let me know.
- I will add "(Updated – *date*)" next to each presentation on my web site that has been updated since these have been uploaded to the FTP center.

Thanks! Rick



Hub

Hub

11

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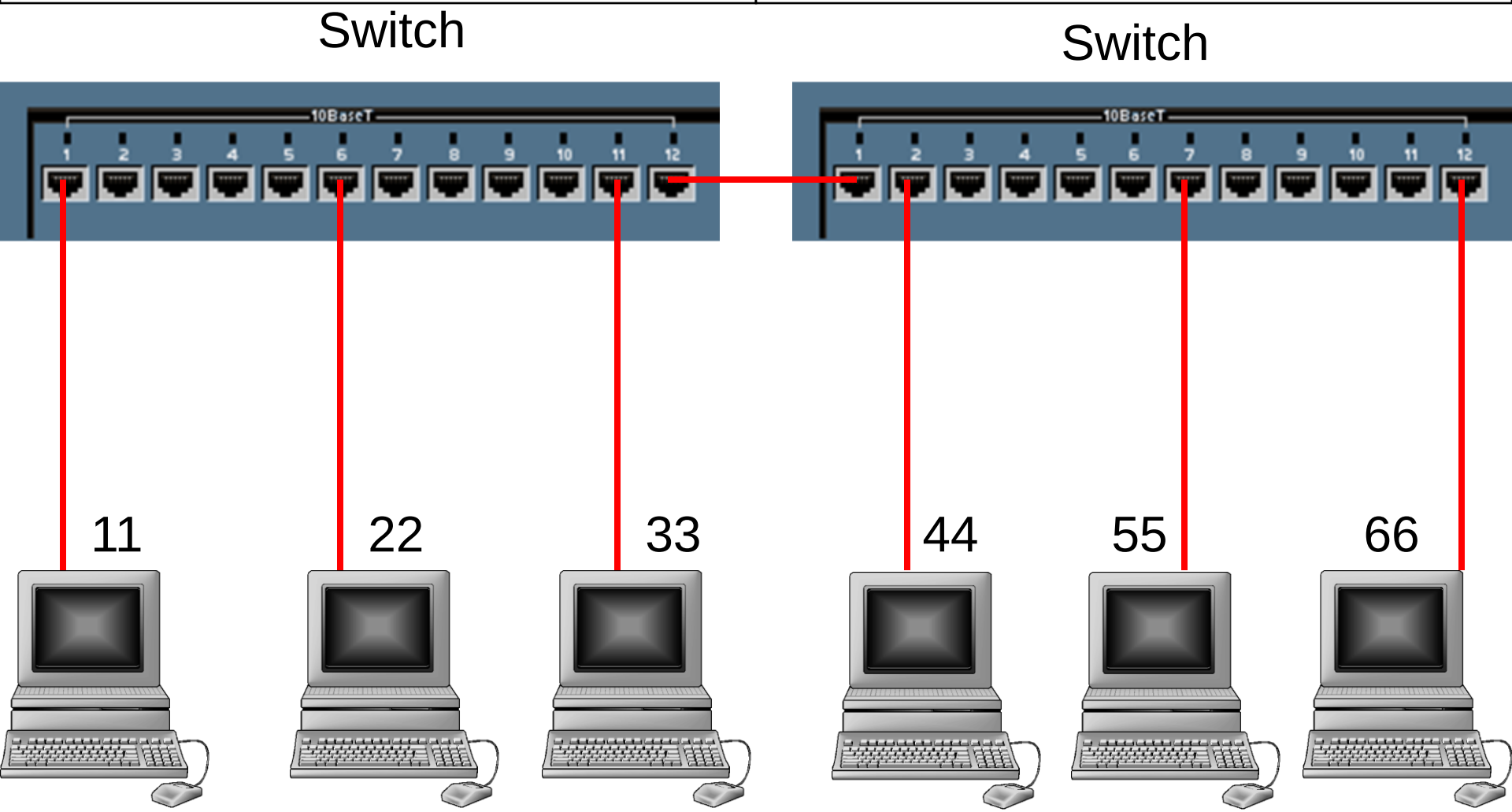
Source Address Table				Source Address Table			
Port	Source MAC Add.	Port	Source MAC Add.	Port	Source MAC Add.	Port	Source MAC Add.

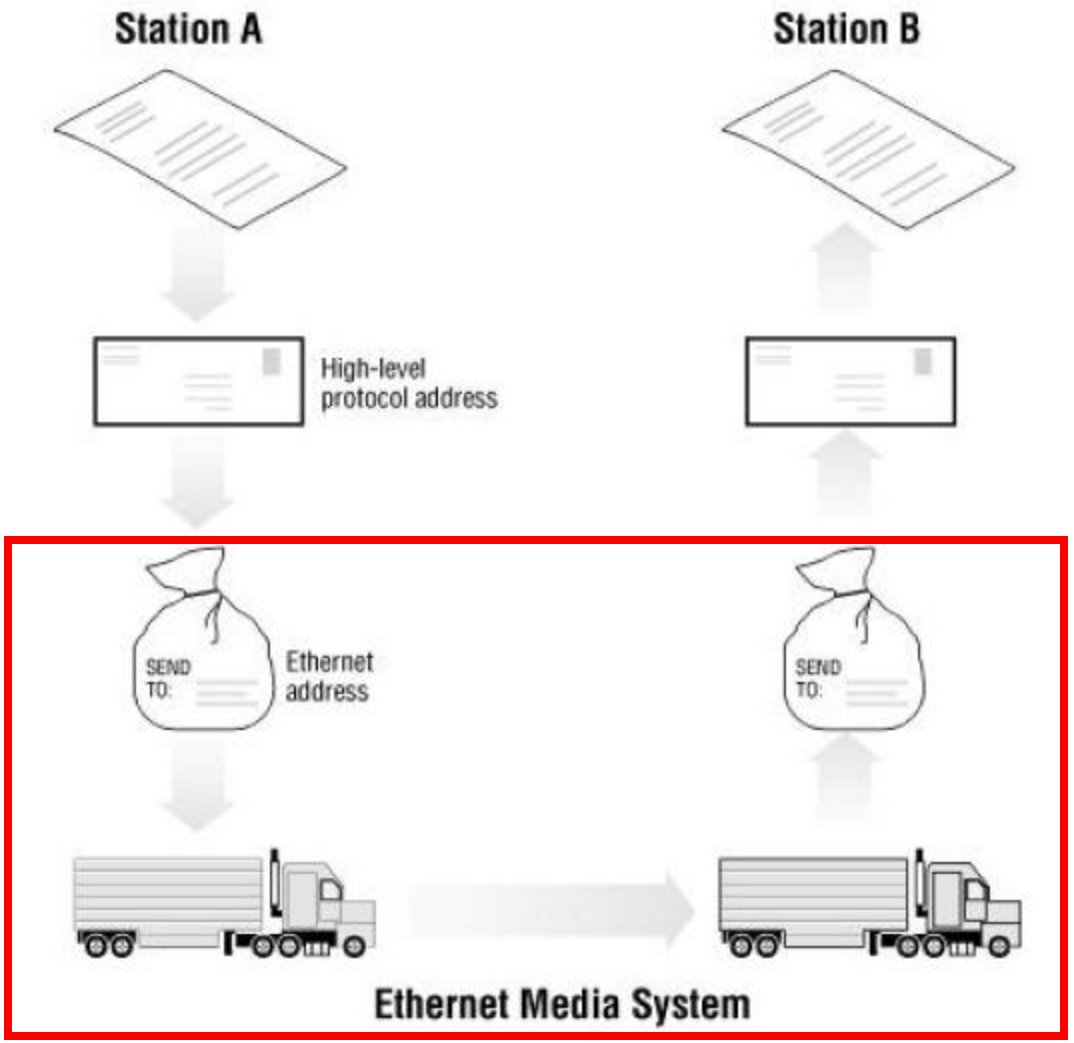


Evolution of the Ethernet Standard

- **1979** Bob Metcalfe developed Ethernet at XEROX PARC
- **1980** DEC-Intel-Xerox (DIX) publish first original 10 Mbps Ethernet Standard over thick coaxial cable
- **1985** IEEE 802.3 used DIX standard and published standard with the title *IEEE 802.3 Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications*
- **Supplements**
  - 1985 10BASE2 Thin Ethernet
  - 1990 10BASE-T Twisted-pair
  - 1995 100BASE-T Fast Ethernet and Autonegotiation
  - 1997 Full Duplex Standard
  - 1998 1000BASE-X Gigabit Ethernet

Ethernet is Best Effort Delivery

- Ethernet is best-effort delivery, no guarantee.
- Like a trucking service, it doesn't really know or care about the what it is carrying.

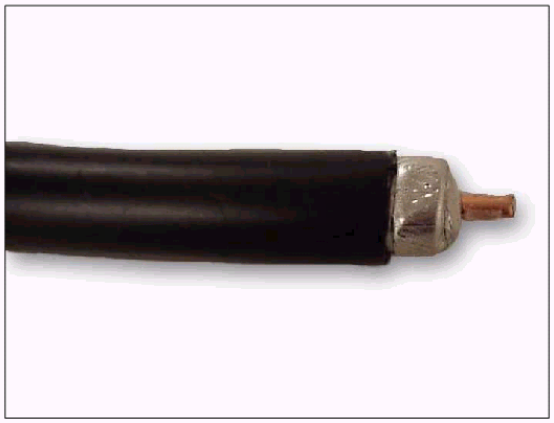


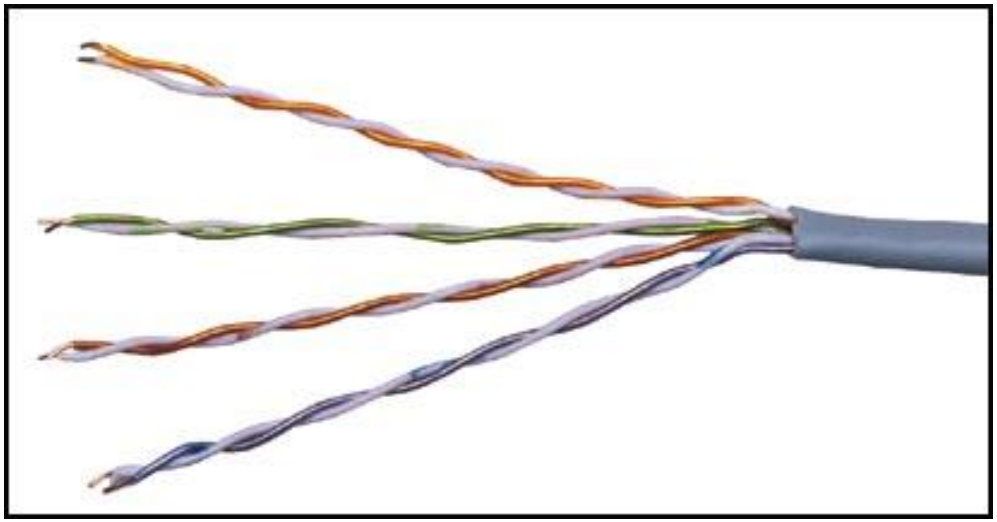
IEEE Identifiers

Early Standards	Older Fiber Standards	100 Mbps Media	1000 Mbps Media
10BASE5	10BASE-F	100BASE-T	1000BASE-X
10BASE2	10BASE-FB	100BASE-X	1000BASE-SX
FOIRL	10BASE-FP	100BASE-TX	1000BASE-LX
10BROAD36	10BASE-FL	100BASE-FX	1000BASE-CX
1BASE5		100BASE-T4	1000BASE-T
10BASE-T		100BASE-T2	
Many of these standards were short lived or never implemented			

- 3 part identifier
  - Speed in Mbps
  - Type of signaling used (Baseband or Broadband)
  - Distance or Medium
    - Early days: Cable Distance in meters, rounded to the nearest 100 meters
    - Later days: Physical medium used

IEEE Identifiers

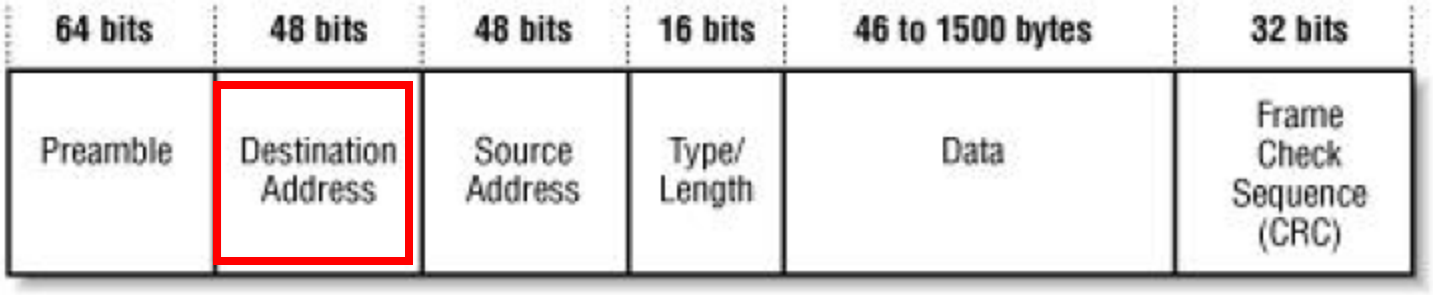




- 10BASE5 (Thick Ethernet)
  - 10 refers to 10 Mbps
  - **Baseband**: Dedicated to carrying one type of service
  - **Broadband**: (Cable television) Designed to deliver multiple channels
  - 5 refers to 500 meter maximum distance

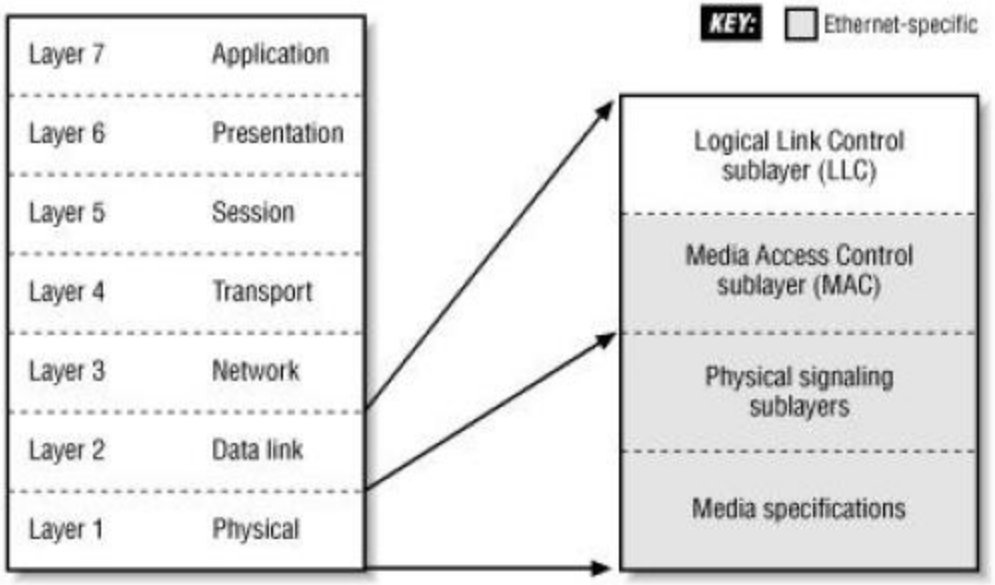
- 100BASE-TX (Most widely used variety of Fast Ethernet)
  - 100 refers to 100 Mbps
  - TX Two pairs of Category 5 Twisted-pair cable

Unicast, Multicast, Broadcast Destination Addresses



- **Unicast address**: A single Ethernet frame to be received by a single station.
  - **Unknown Unicast**: This is from the perspective of a switch, when the unicast address is not in its MAC Address Table
- **Multicast address**: A single Ethernet frame to be received by a group of stations.
- **Broadcast address**: Special case of a multicast address, which is all 1's. This is an Ethernet frame to be received by all stations.

Media Access Control Protocol



- Original Ethernet standard based on CSMA/CD media access control (MAC)
- Also known as Half-duplex mode
- No need for CSMA/CD in Full-duplex mode (later)
- Compete for a shared Ethernet channel in a fair and equitable manner

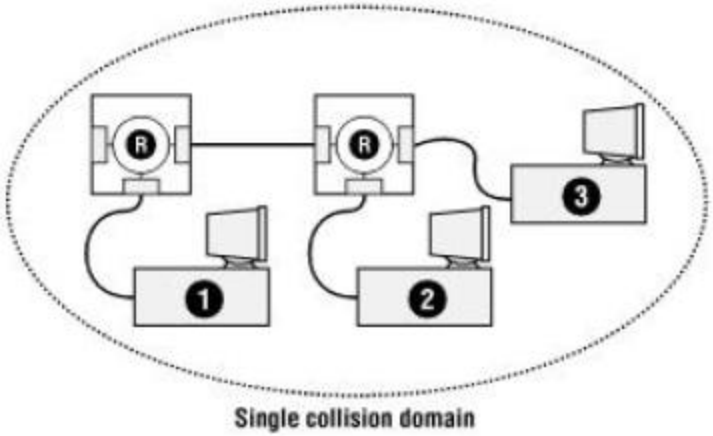
Duplex Transmissions

- **Simplex Transmission**: One way and one way only.
  - One way street
- **Half-duplex Transmission**: Either way, but only one way at a time.
  - Two way street, but only one way at a time (land slide).
- **Full-duplex Transmission**: Both ways at the same time.
  - Two way street

IFG – Interframe Gap

- Ethernet devices must allow a minimum idle period between transmission of frames known as the **interframe gap (IFG)** or interpacket gap (IPG).
- Note: Both half and full-duplex
- It provides a brief recovery time between frames to allow devices to prepare for reception of the next frame.
- The minimum interframe gap is:
  - **10 Mbps Ethernet**: 96 bit times, which is 9.6 microseconds (millionths of a second)
  - **100 Mbps, Fast Ethernet**: 960 nanoseconds (billionths of a second)
  - **1000 Mbps**, **Gigabit Ethernet**: 96 nanoseconds
- Note: 802.11 (WLAN) uses similar

Collisions, Slot time and Minimum Frame Size

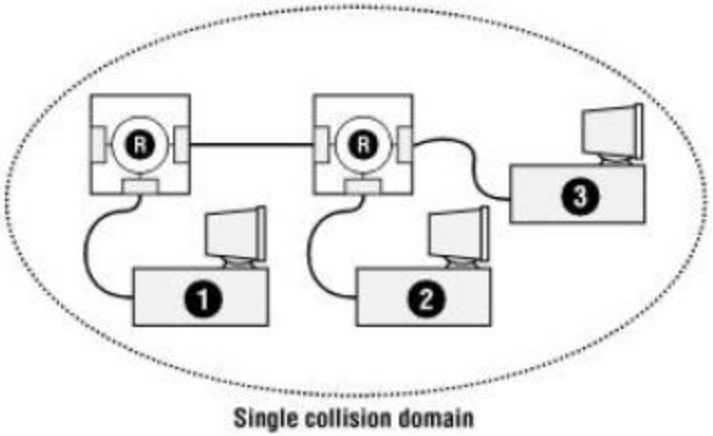


Single collision domain

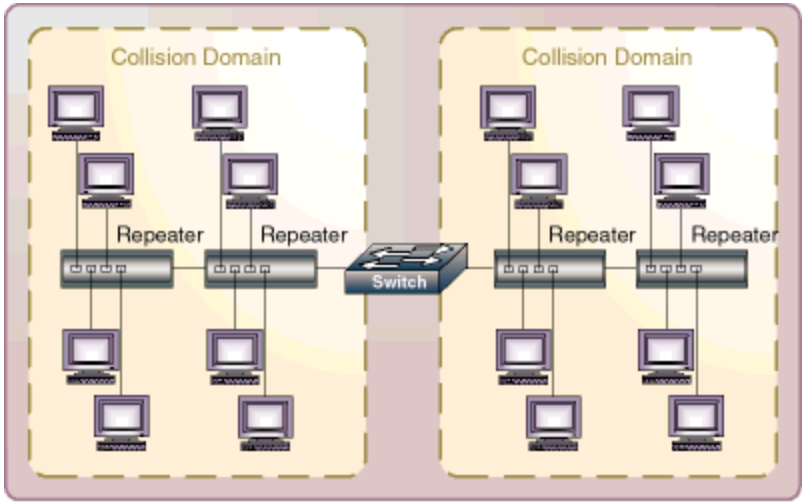
Notes

- Original Ethernet (802.3) designed as Half-duplex
- CSMA/CD is based on half-duplex and is NOT part of full-duplex
- Collisions are part of CSMA/CD and half-duplex Ethernet
- Collisions are a normal part of operation and are NOT errors
- Collisions are NOT part of full-duplex Ethernet

Collision Domain



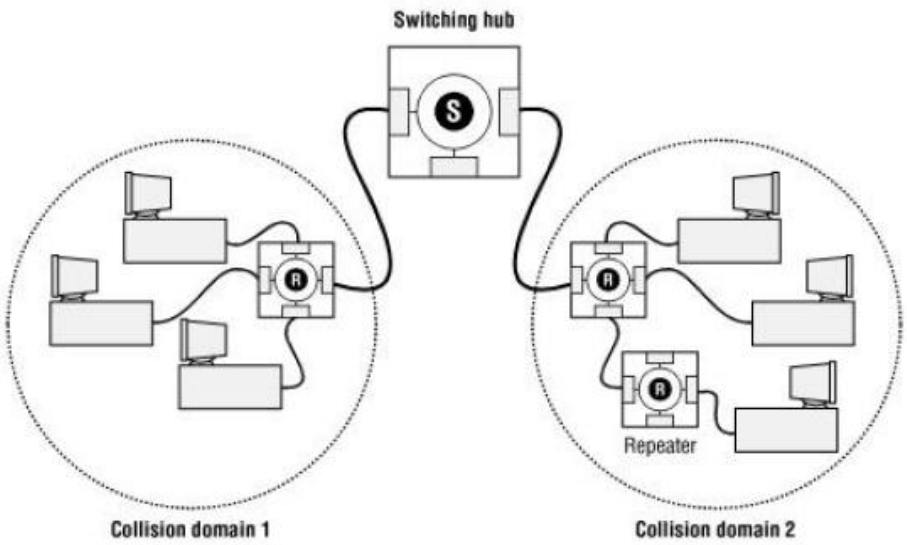
Single collision domain

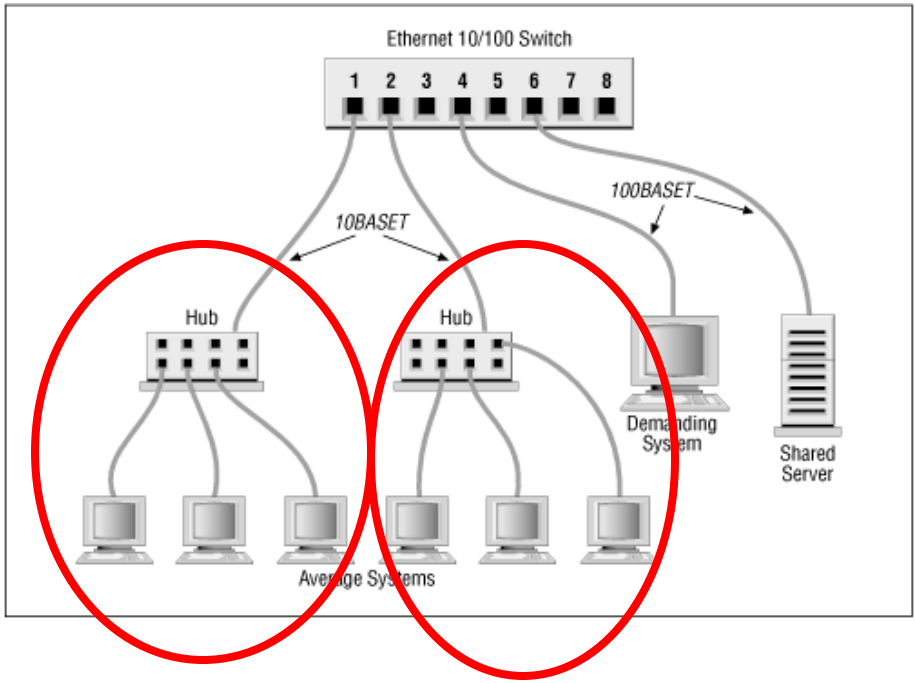


[NA-VLAN-WP1-02]

- **Collision Domain**: Refers to a single half-duplex Ethernet system whose elements (cables, repeaters, hubs, station interfaces and other network hardware) are all part of the same signal timing domain.
- If two or more devices transmit at the same time a collision will occur.
- If a collision is detected, the station will continue to transmit 32 bits called the **collision enforcement jam signal**.

Collision Domain

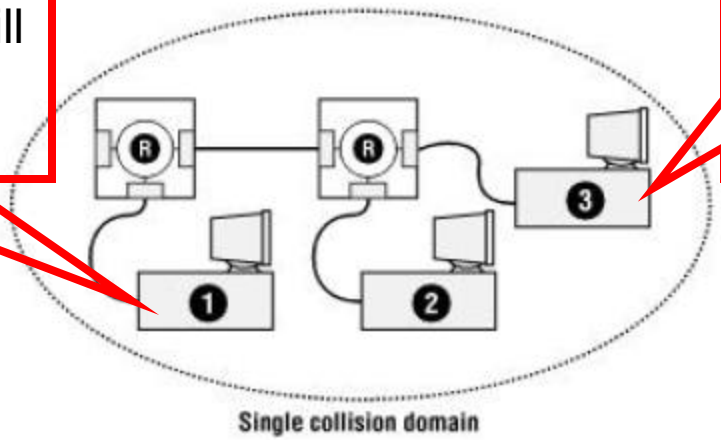




- Switches do not forward collision signals

Slot Time and Maximum Cable Length

If a collision occurs it will be within the first 512 bits that I send.

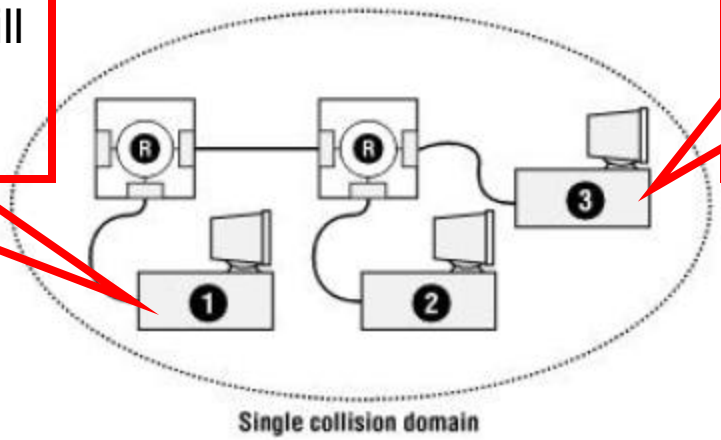


If a collision occurs it will be within the first 512 bits that I send.

- **Slot time**
  - Time it takes for a signal to travel from one end of the maximum-sized system to the other end and return (round trip propagation time) within a collision domain.
  - Maximum time required by collision enforcement.
  - After this amount of time (or bits), device assumes no collision.
- Ethernet and Fast Ethernet
  - Slot time = 512 bit times (the time it takes to transfer 512 bits)

Slot Time and Maximum Cable Length

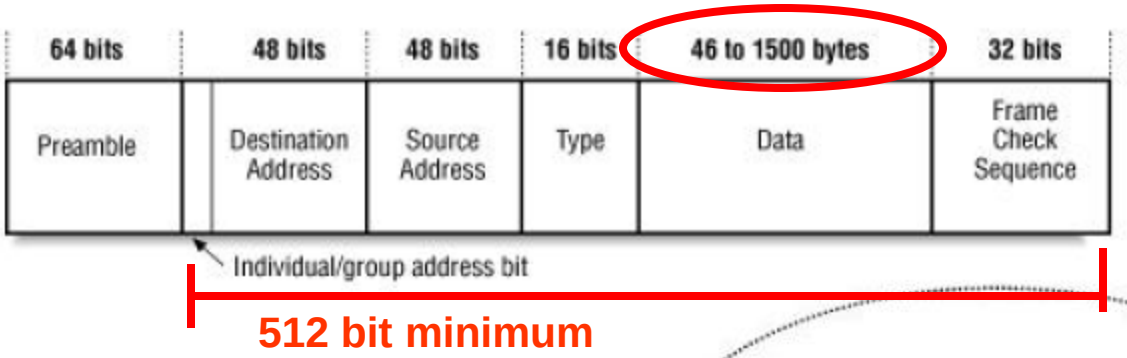
If a collision occurs it will be within the first 512 bits that I send.

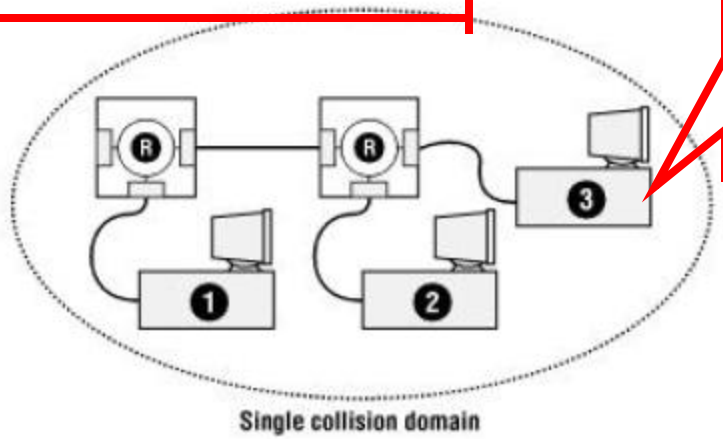


If a collision occurs it will be within the first 512 bits that I send.

- Slot time and maximum cable length are tightly coupled.
  - Original 10 Mbps Ethernet: On coaxial cable, signals could travel 2,800 meters (9,186 feet) and back in 512 bit times.
  - Maximum distance of collision domain is 2,800 meters.
  - In other words, a station would know about a collision (rise in DC signal level) before it transmitted the 513th bit.
- Fast Ethernet Twisted-pair maximum network diameter is 205 meters or 672 feet, but is limited by cabling standards of 100 meters or 328 feet. (Remember, more bits per second, shorter bits, than Ethernet)

Slot Time and Maximum Cable Length

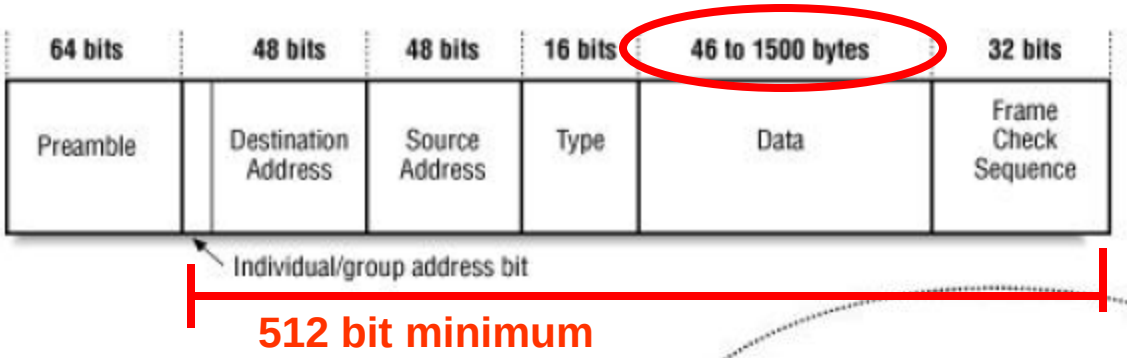


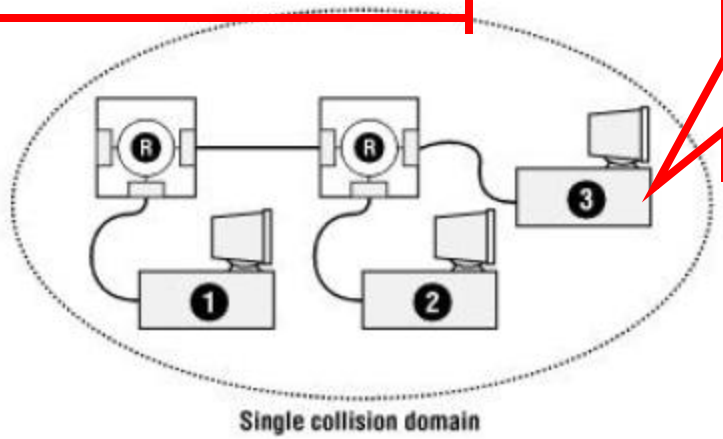


If a collision occurs it will be within the first 512 bits that I send.

- 512 bit Slot Time
  - Destination Address = 48 bits
  - Source Address = 48 bits
  - Type = 16 bits
  - Data = 368 bits or (46 bytes * 8 bits per byte)
  - FCS = 32 bits
- ***This is why there is a <u>minimum of 46 bytes of data</u>!***

Slot Time and Maximum Cable Length





If a collision occurs it will be within the first 512 bits that I send.

- A collision will be noticed within the first 512 bits transferred, so the minimum frame size must be 512 bits.
- After 512 bits, the sending station assumes no collisions.
- At 513 bits, all stations on the entire Ethernet system, collision domain (cable, repeaters, hubs) should have seen this frame by now before they begin transmitting.
- This is why there is a maximum size to the Ethernet system. (Half-duplex only!)

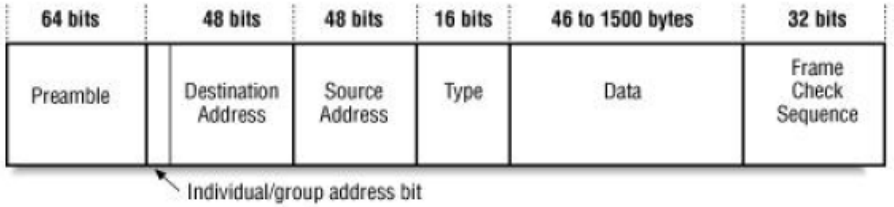
Questions from Reading Assignment

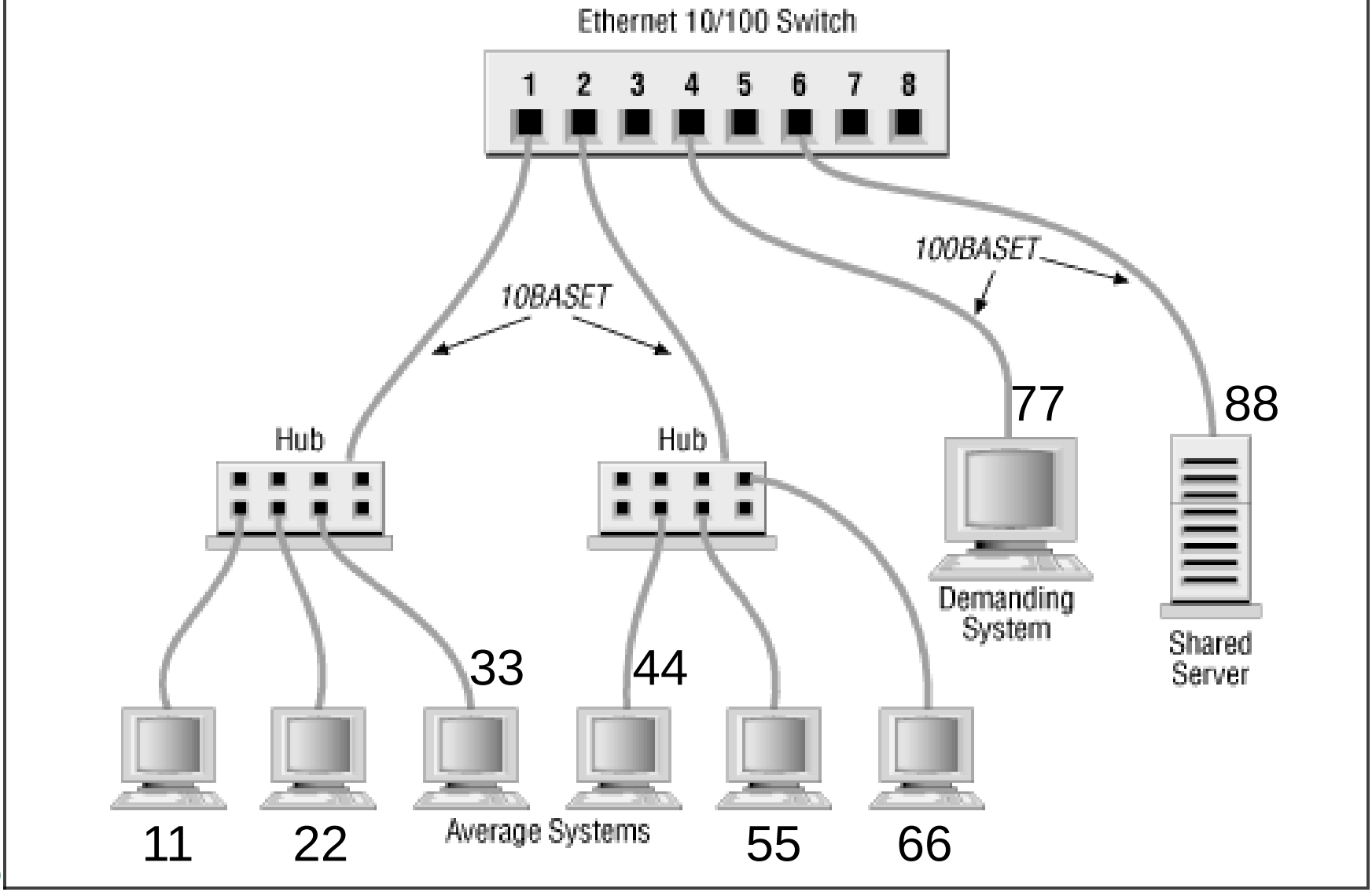
In your reading assignment you will learn about:

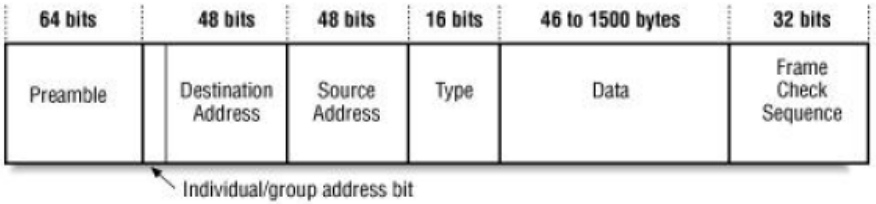
- Dribble Bits
- Acquired Channel
- Late Collisions
- And more…

Source Address Table

Port	Source MAC Add.	Port	Source MAC Add.





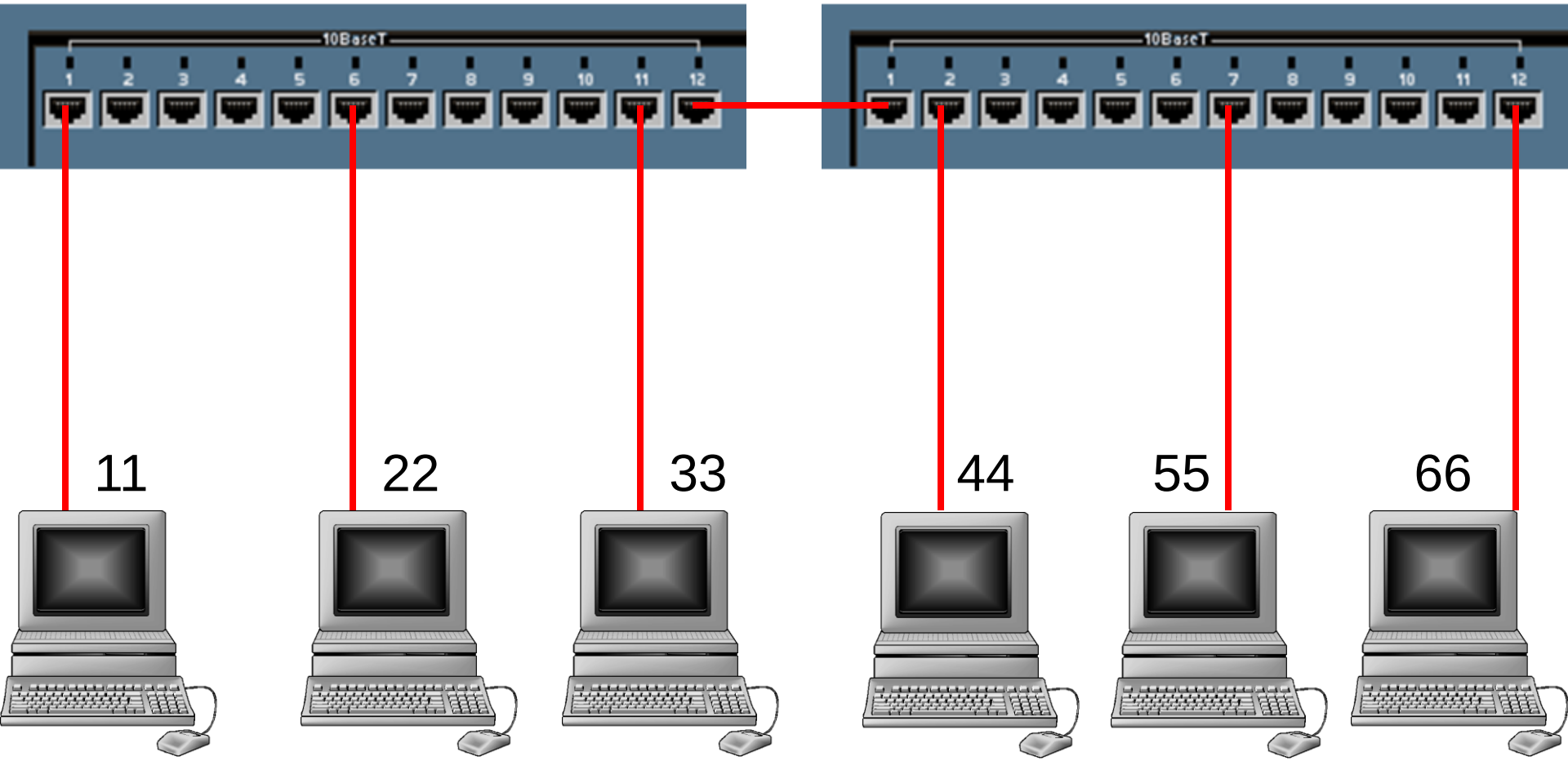


Source Address Table

Port	Source MAC Add.	Port	Source MAC Add.

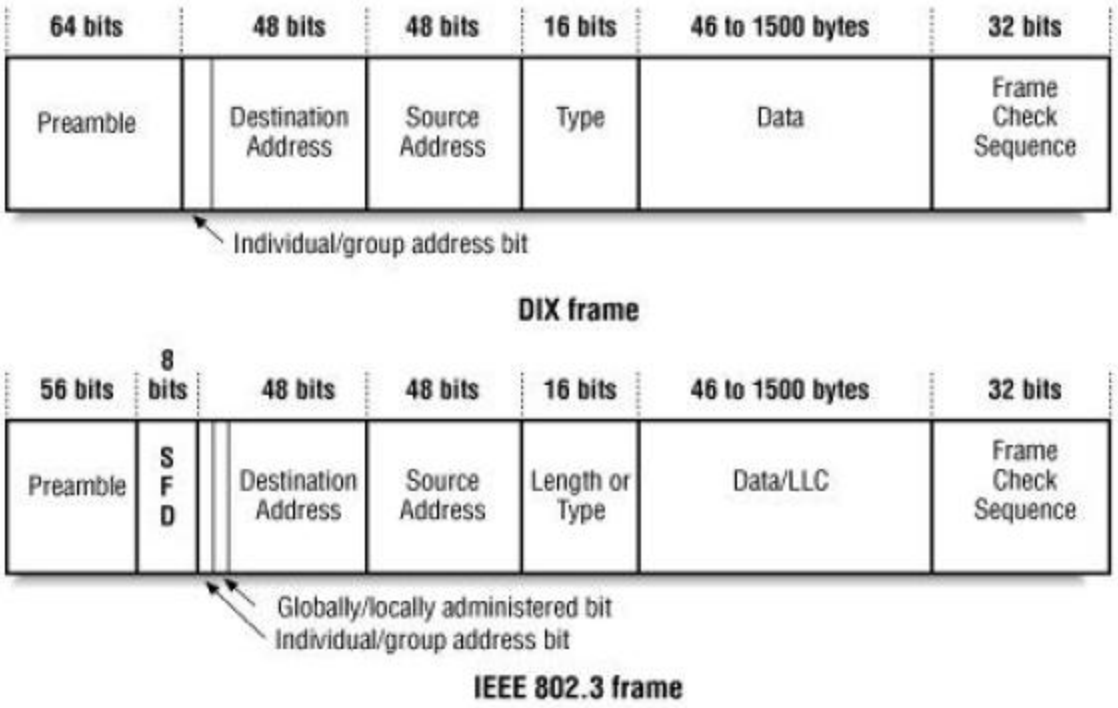
Hub

Switch



A Closer Look at Frames (FYI)

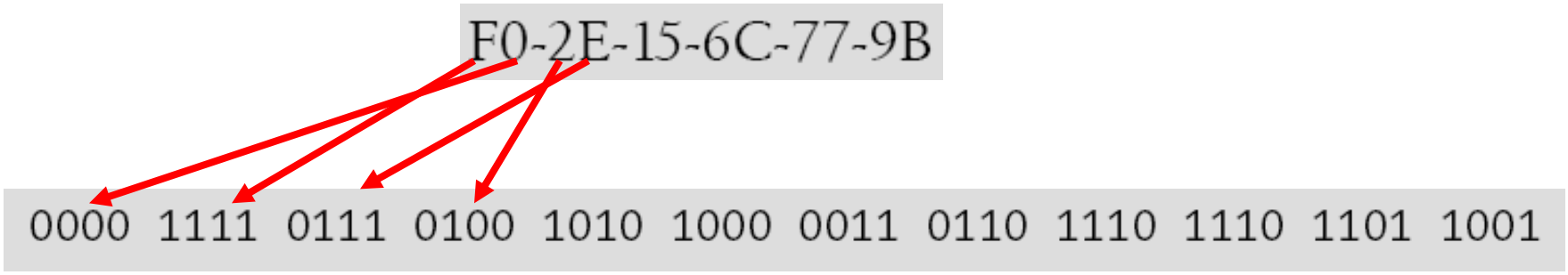
A closer look at the frames



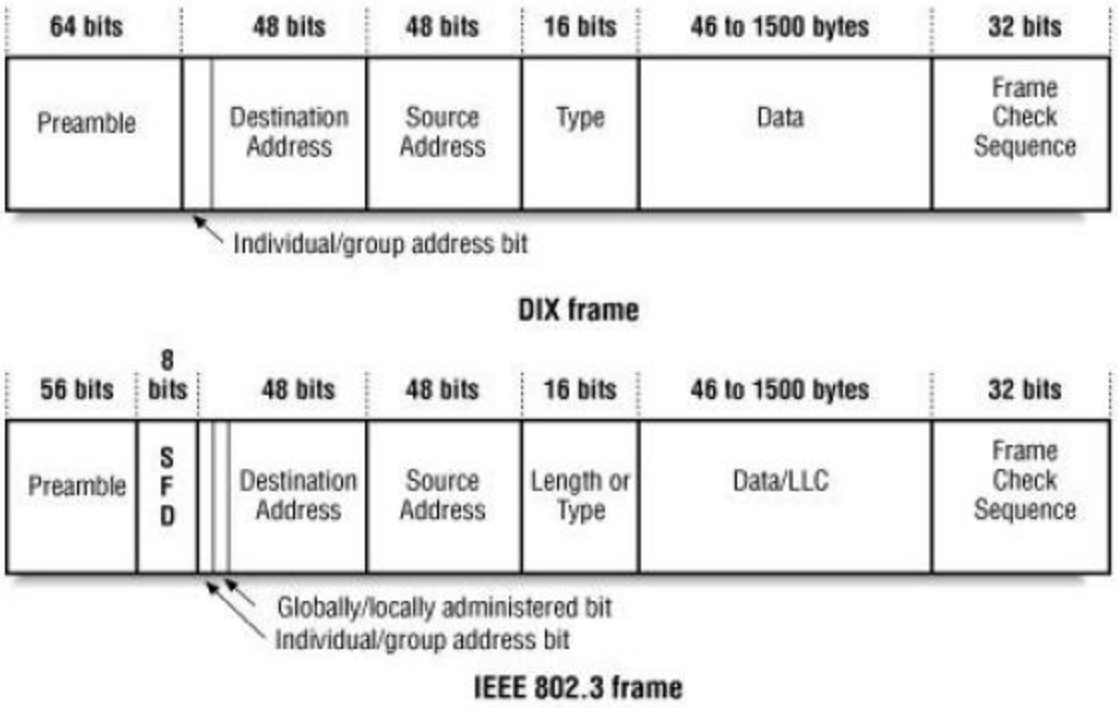
- **Preamble**
  - Allows NIC to synchronize themselves with incoming data stream
  - Allows beginning of the frame to lose a few bits due to start-up delays
  - Like a heat shield of a spacecraft
  - Fast Ethernet and Gigabit Ethernet do not need preamble, but is preserved for backwards compatibility.
- No practical difference between DIX and 802.3
  - 802.3 divides preamble into two parts including SFD (Start Frame Delimeter)

Destination Address

- First bit of Destination Address:
  - 0 = Unicast Address
  - 1 = Multicast or Broadcast Address
- 802.3 adds significance to the 2nd bit of Destination Address
  - 0 = Globally Administered, assigned by manufacturer
  - 1 = Locally Administered, assigned by administrator (very rare!)
- 48 bit address can be written as 12 hexadecimal digits
  - Leftmost octet of bits written as rightmost hexadecimal octet
  - Actual transmission order of the octet, is least significant bit to most significant bit. [2E = 0010 1110 would be transmitted as 0111 0100]

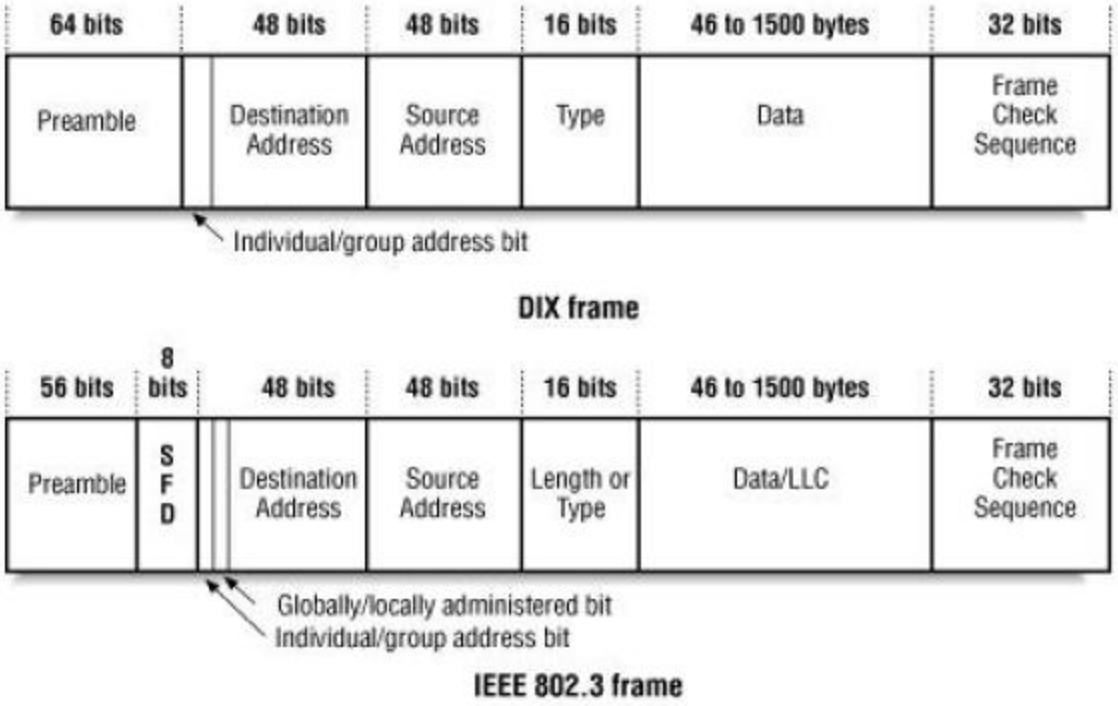


Type or Length Field



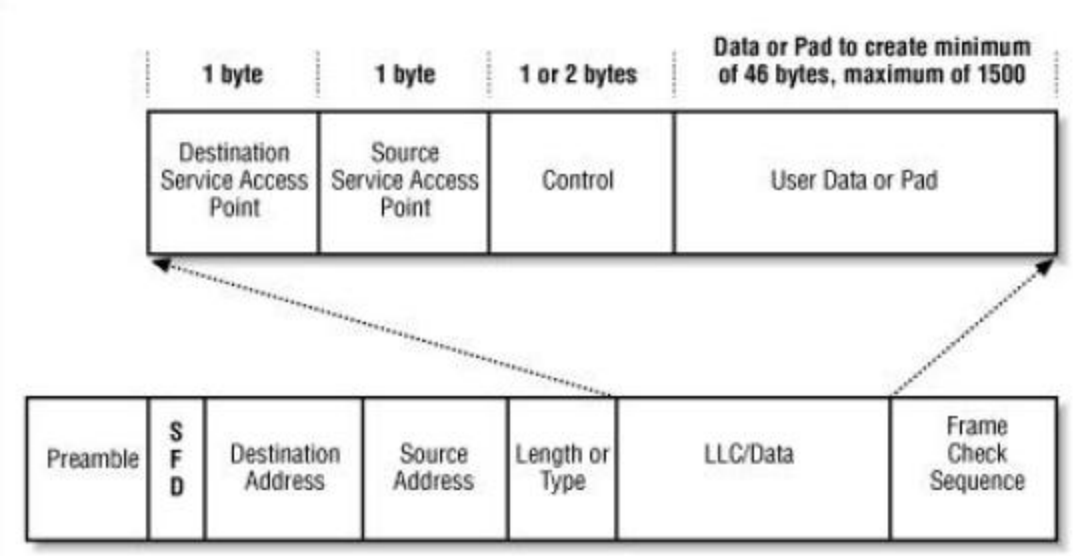
- DIX
  - Type field: refers to high-level protocol being carried
  - 0x800 = IP
- 802.3
  - < 1500 (decimal) = length field
    - Number of bits carried in the data field, less any padding
  - >= 1536 (0x600 hex) = type field, same as DIX

Data Field



- DIX
  - Minimum 46 bytes, maximum 1500 bytes
  - Layer 3, network protocol, software expected to proved at least 46 bytes of data
- 802.3
  - Minimum 46 bytes, maximum 1500 bytes
  - May include LLC protocol for control information to identify type of data being carried, similar to DIX type field

802.3 Data Field

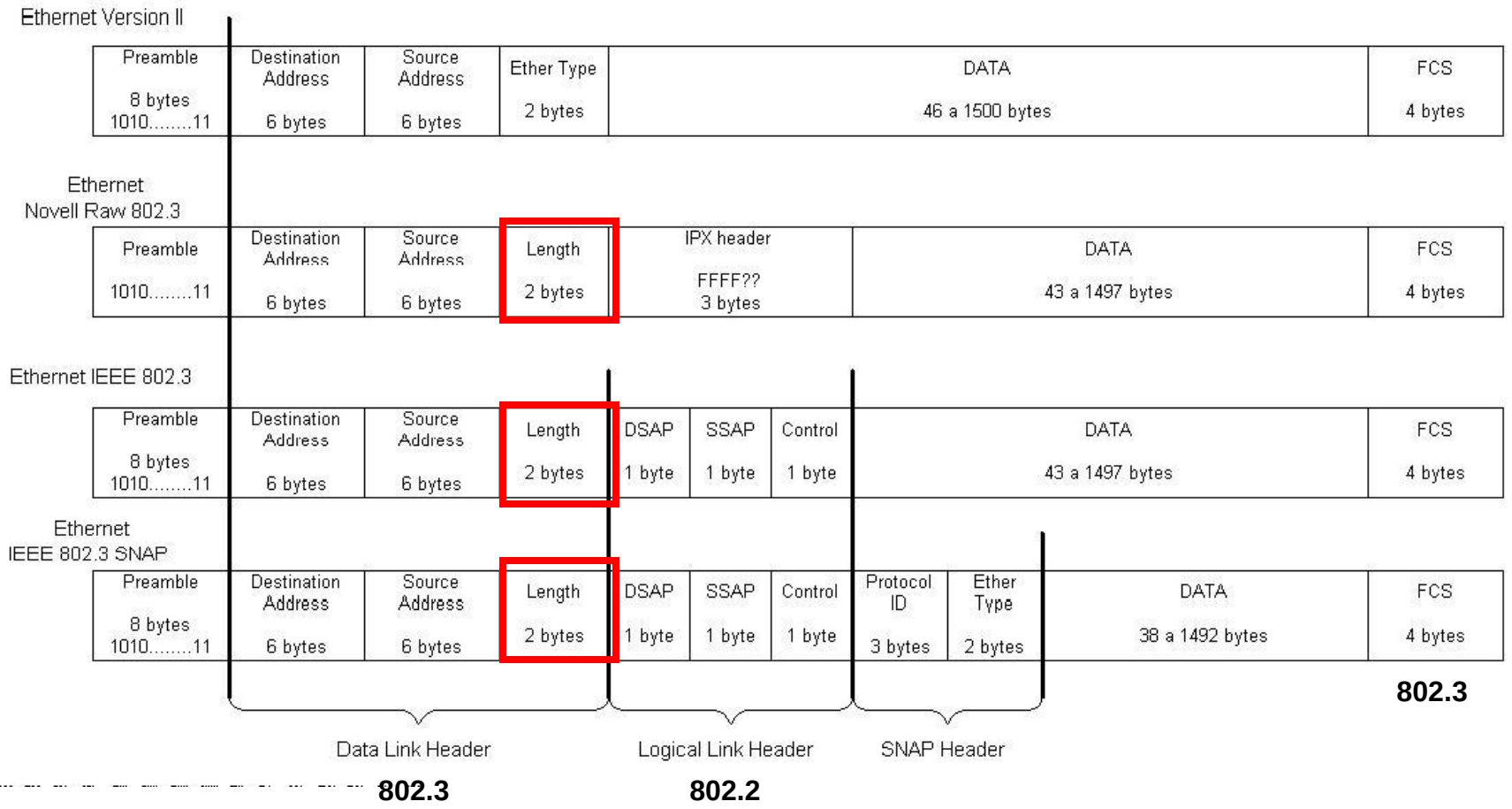


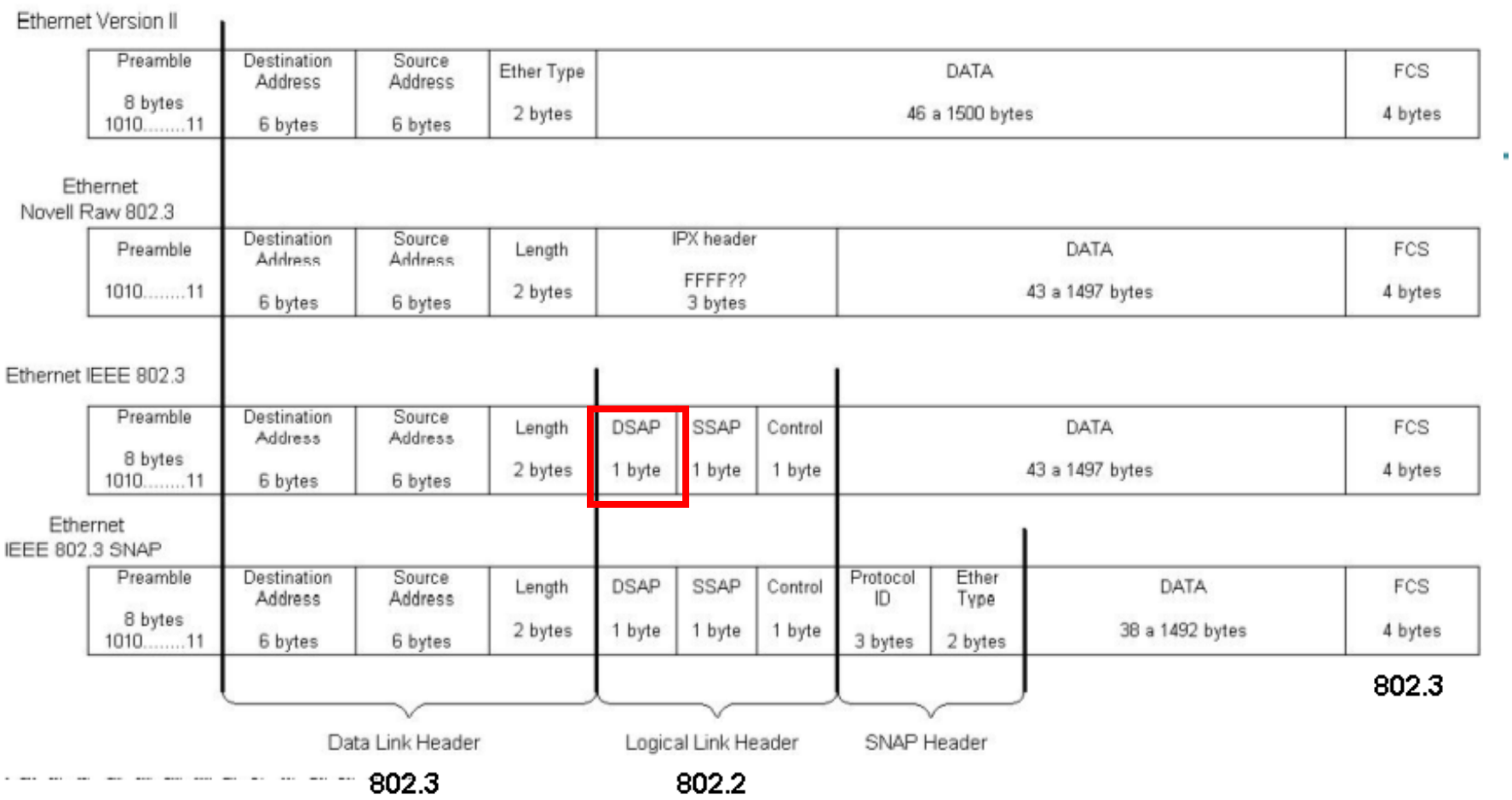
- Destination Service Access Point (DSAP) and Source Service Access Point (SSAP) are similar to DIX type field.
- ***To sum all of this up…***

“Ethernet” Frame Formats

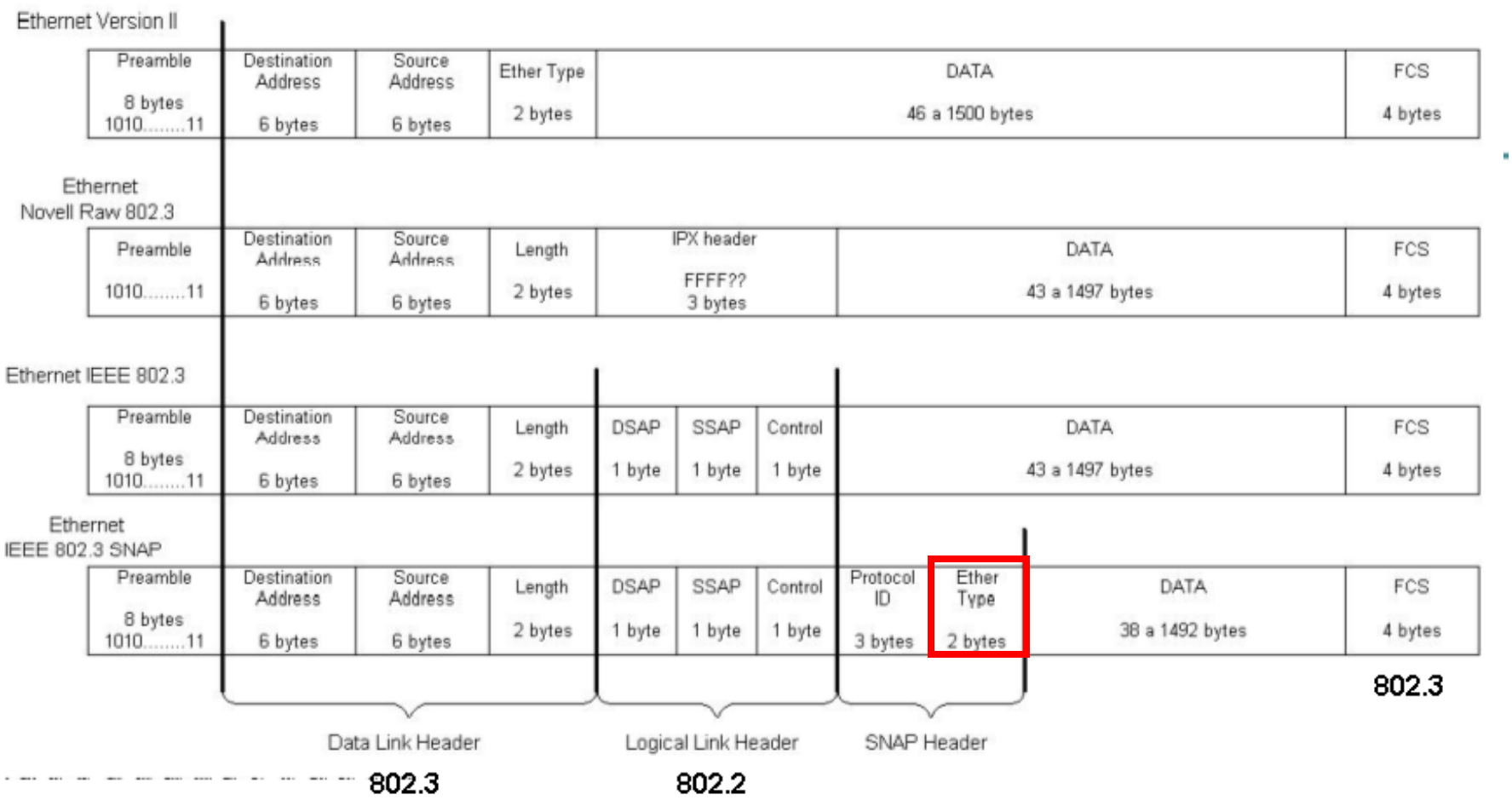
Length Field

- In some frame formats such as 802.3, there is a length field which specifies the exact length of a frame.

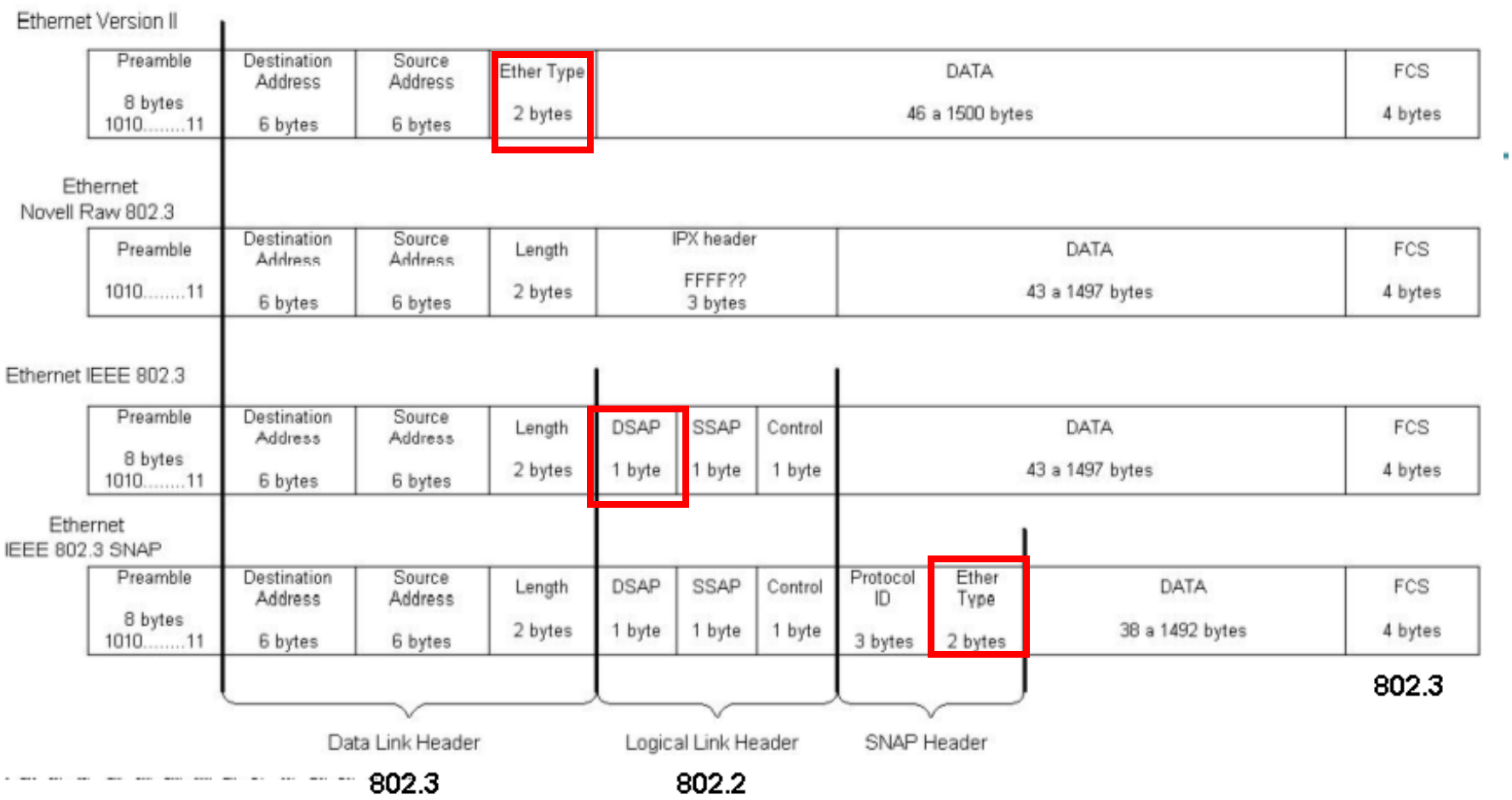




- IEEE 802.3 specification limits the data portion to a maximum of 1500 bytes.
- Designed to hold a Layer 3 IP packet.
- When IEEE created 802.2, it saw the need for a protocol TYPE field that identified what was inside the “data” field.
- IEEE called its 1 byte type field DSAP (Destination Service Access Point).
- Turned out that 1 byte was not long enough to handle all the different number of protocols.

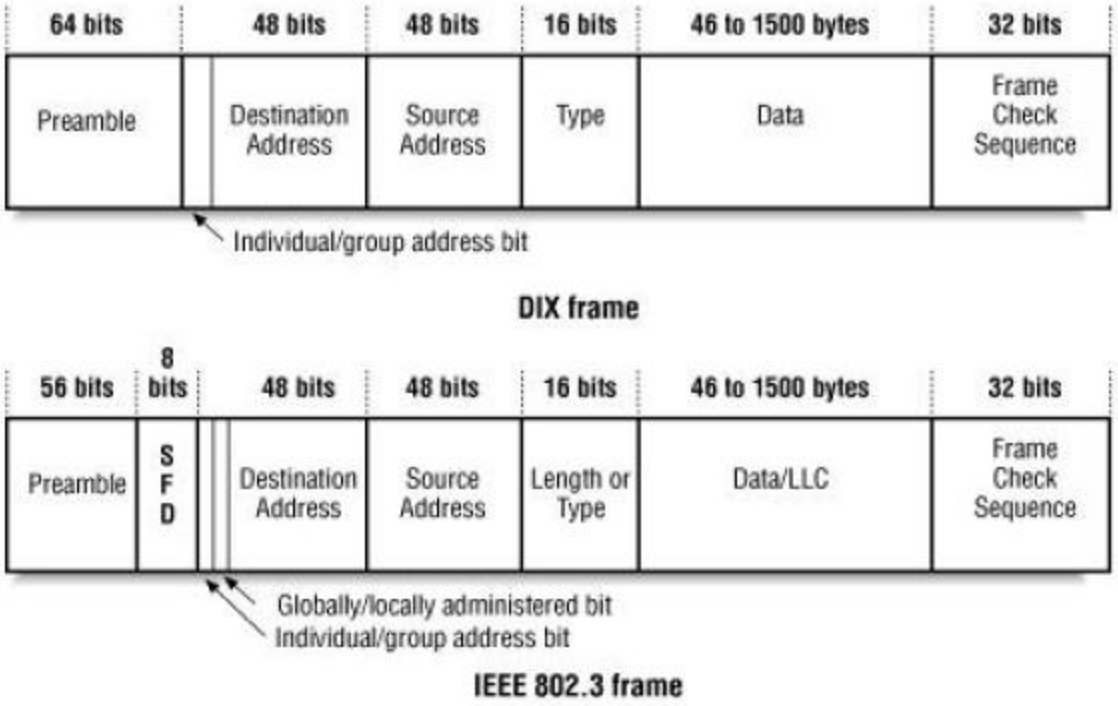


- To accommodate more protocols IEEE added the SNAP (Subnetwork Access Protocol) header.



- The fields of various Ethernet framing that are used for identifying the type of data contained in a frame:
  - **Ethernet II** or DIX (DEC, Intel, Xerox) – Most common
  - IEEE Ethernet (802.3)
  - IEEE 802.3 with SNAP header

FCS



- Frame Check Sequence (FCS)
  - Uses CRC (Cyclic Redundancy Check)
  - Checks integrity of all fields except preamble/SFD
  - Calculation using contents of destination, source, type or length and data fields.
  - CRC calculated again by received NIC
  - If calculations differ, frame is dropped

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